Screening Assessment for the Challenge

Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, (1,2-dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl) ester (**Benzenepropanoic acid ester**)

Chemical Abstracts Service Registry Number
70331-94-1

Environment Canada
Health Canada

July 2010

Synopsis

Pursuant to section 74 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), the Ministers of the Environment and of Health have conducted a screening assessment on Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, (1,2-dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl) ester (benzenepropanoic acid ester), Chemical Abstracts Service Registry Number 70331-94-1. This substance was identified as a high priority for screening assessment and included in the Challenge because it had been found to meet the ecological categorization criteria for persistence, bioaccumulation potential and inherent toxicity to non-human organisms and is believed to be in commerce in Canada.

The substance benzenepropanoic acid ester was not considered to be a high priority for assessment of potential risks to human health, based upon application of the simple exposure and hazard tools developed by Health Canada for categorization of substances on the *Domestic Substances List*. Therefore, this assessment focuses primarily on information relevant to the evaluation of ecological risks.

Benzenepropanoic acid ester is an organic substance that is used in Canada as an antioxidant in plastics. The substance is not naturally produced in the environment. It is not reported to be manufactured in Canada; however, a total of 153 kg were imported into Canada in 2006.

Based on reported use patterns in Canada and certain assumptions, most of the substance ends up in waste disposal sites. About 4% is estimated to be released to water, and 4% to soil. Benzenepropanoic acid ester has very low predicted water solubility. It is not volatile, and it has a tendency to partition mainly to sediments if released to surface waters, and to soils if released to soils or air.

Based on its physical and chemical properties and data from selected chemical analogues, benzenepropanoic acid ester is persistent in water, soil and sediment. It has a high modelled log K_{OW} value of 6.68. However, new modelled bioaccumulation data that take into account biotransformation suggests that this substance has a low potential to accumulate in the lipid tissues of organisms. The substance therefore meets the persistence criteria but does not meet the bioaccumulation criteria as set out in the *Persistence and Bioaccumulation Regulations*.

For this screening assessment, a very conservative exposure scenario was selected in which an industrial operation (plastics manufacturer) discharges benzenepropanoic acid ester into the aquatic environment. The predicted environmental concentration in water was one order of magnitude smaller than the predicted no-effect concentration.

Therefore, it is concluded that benzenepropanoic acid ester is not entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity, or that constitute or may constitute a danger to the environment on which life depends.

Exposure of the general population in Canada to benzenepropanoic acid ester from environmental media is expected to be negligible based on the limited amount imported into Canada on an annual basis. The principal source of exposure to benzenepropanoic acid ester for the general population is expected to be through food (i.e., migration from food packaging materials).

The human health effects database for benzenepropanoic acid ester is moderate; however the available empirical data and information from predictive models are not suggestive of high hazard. Based on the available information, the margins between the probable daily intake estimated from food packaging materials and levels associated with effects in experimental animals are considered to be adequately protective. Therefore, it is concluded that benzenepropanoic acid ester is not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

Based on the information available, benzenepropanoic acid ester does not meet any of the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999*.

This substance will be considered for inclusion in the *Domestic Substances List* inventory update initiative. In addition and where relevant, research and monitoring will support verification of assumptions used during the screening assessment.

Introduction

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada 1999) requires the Minister of the Environment and the Minister of Health to conduct screening assessments of substances that have met the categorization criteria set out in the Act to determine whether these substances present or may present a risk to the environment or human health.

Based on the information obtained through the categorization process, the Ministers identified a number of substances as high priorities for action. These include substances that

- met all of the ecological categorization criteria, including persistence (P), bioaccumulation potential (B) and inherent toxicity to aquatic organisms (iT), and were believed to be in commerce in Canada; and/or
- met the categorization criteria for greatest potential for exposure (GPE) or presented an intermediate potential for exposure (IPE), and had been identified as posing a high hazard to human health based on classifications by other national or international agencies for carcinogenicity, genotoxicity, developmental toxicity or reproductive toxicity.

The Ministers therefore published a notice of intent in the *Canada Gazette*, Part I, on December 9, 2006 (Canada 2006a), that challenged industry and other interested stakeholders to submit, within specified timelines, specific information that may be used to inform risk assessment, and to develop and benchmark best practices for the risk management and product stewardship of those substances identified as high priorities.

The substance Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, (1,2-dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl) ester was identified as a high priority for assessment of ecological risk as it was found to be persistent, bioaccumulative and inherently toxic to aquatic organisms and is believed to be in commerce in Canada.

The Challenge for this substance was published in the *Canada Gazette* on January 31, 2009 (Canada 2009a, 2009b). A substance profile was released at the same time. The substance profile presented the technical information available prior to December 2005 that formed the basis for categorization of this substance. As a result of the Challenge, submissions of information pertaining to the uses and exposure of the substance were received.

Although Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, (1,2-dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl) ester was determined to be a high priority for assessment with respect to the environment, it did not meet the criteria for GPE or IPE, or high hazard to human health based on classifications by other national or international agencies for carcinogenicity, genotoxicity, developmental toxicity or reproductive toxicity. Therefore, this assessment focuses principally on information relevant to the evaluation of ecological risks.

Screening assessments focus on information critical to determining whether a substance meets the criteria for defining a chemical as toxic as set out in section 64 of CEPA 1999. Screening assessments examine scientific information and develop conclusions by incorporating a weight-of-evidence approach and precaution.[1]

This screening assessment includes consideration of information on chemical properties, hazards, uses and exposure, including the additional information submitted under the Challenge. Data relevant to the screening assessment of this substance were identified in original literature, review and assessment documents, stakeholder research reports and from recent literature searches, up to August 2009 for the ecological sections of the document and November 2009 for the human health–related sections. Key studies were critically evaluated. Modelling results and empirical information from chemically similar substances were used to reach conclusions. When available and relevant, information presented in hazard assessments from other jurisdictions was also considered. The screening assessment does not represent an exhaustive or critical review of all available data. Rather, it presents the most critical studies and lines of evidence pertinent to the conclusion.

This screening assessment was prepared by staff in the Existing Substances Programs at Health Canada and Environment Canada and incorporates input from other programs within these departments. The ecological portions of this assessment have undergone external peer review/consultation. Additionally, the draft of this screening assessment was subject to a 60-day public comment period. While external comments were taken into consideration, the final content and outcome of the screening assessment remain the responsibility of Health Canada and Environment Canada. Approaches used in the screening assessments under the Challenge have been reviewed by an independent Challenge Advisory Panel.

The critical information and considerations upon which the assessment is based are summarized below.

[1] A determination of whether one or more of the criteria of section 64 are met is based upon an assessment of potential risks to the environment and/or to human health associated with exposures in the general environment. For humans, this includes, but is not limited to, exposures from ambient and indoor air, drinking water, foodstuffs, and the use of consumer products. A conclusion under CEPA 1999 on the substances in the Chemicals Management Plan (CMP) Challenge Batches 1-12 is not relevant to, nor does it preclude, an assessment against the hazard criteria specified in the *Controlled Products Regulations*, which is part of regulatory framework for the Workplace Hazardous Materials Information System [WHMIS] for products intended for workplace use.

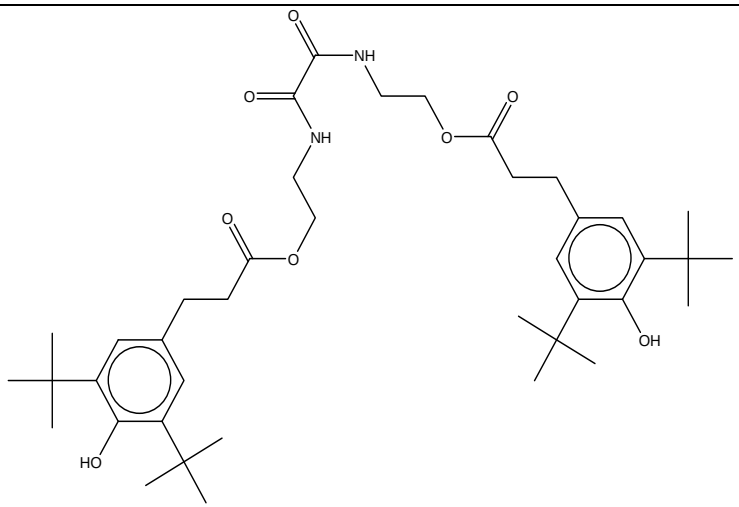
Substance Identity

Substance name

For the purposes of this document, this substance will be referred to as benzenepropanoic acid ester, the common name of the substance.

Table 1. Substance identity for benzenepropanoic acid ester

Chemical Abstracts Service Registry Number (CAS RN)	**70331-94-1**
DSL name	**Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, (1,2-dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl) ester**
National Chemical Inventories (NCI) names[1]	*Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, (1,2-dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl) ester* (TSCA, AICS, ASIA-PAC) *(1,2-dioxoethylene)bis(iminoethylene) bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate]* (EINECS) *Oxalylbis(imino-2,1-ethylene) bis[3,5-di-tert-butyl-4-hydroxybenzenpropionate]* (ENCS) *3,5-Bis(1,1-dimethylethyl)-4-hydroxybenzene-propanoic acid (1,2-dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl) ester* (ECL) *3,5-Bis(1,1-dimethylethyl)-4-hydroxybenzenepropanoic acid (1,2-dioxo-1,2-ethanediyl)bis(imino-2,1-ethanediyl) ester* (ECL)
Other names	*2,2'-Oxalyldiamidobisethyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate;* *2,2'-Oxalyldiamidobisethyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate;* *2,2'-Oxamidobis[ethyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate];* *2,2'-Oxamidodiethyl bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate];* *Naugard XL 1;* *XL 1*
Chemical group (DSL Stream)	Discrete organics
Major chemical class or use	Hindered phenols
Major chemical sub-class	Esters, secondary amines, aliphatic amines
Chemical formula	$C_{40}H_{60}N_2O_8$

Chemical structure	
SMILES[2]	O=C(C(=O)NCCOC(=O)CCc1cc(c(c(c1)C(C)(C)C)O)C(C)(C)C)NCCOC(=O)CCc2cc(c(c(c2)C(C)(C)C)O)C(C)(C)C
Molecular mass	696.9 g/mol

[1] National Chemical Inventories (NCI). 2007: AICS (Australian Inventory of Chemical Substances); ASIA-PAC (Asia-Pacific Substances Lists); DSL (Canada's Domestic Substances List); ECL (Korean Existing Chemicals List); EINECS (European Inventory of Existing Commercial Chemical Substances); ENCS (Japanese Existing and New Chemical Substances); and TSCA (Toxic Substances Control Act Chemical Substance Inventory).

[2] Simplified Molecular Input Line Entry System

Physical and Chemical Properties

Almost no experimental data were identified for the physical and chemical properties of benzenepropanoic acid ester. Table 2a contains mainly modelled physical and chemical properties of benzenepropanoic acid ester that are relevant to its environmental fate.

The models are based on quantitative structure-activity relationships (QSARs). These models (except WSKOWWIN 2000) are mainly based on fragment addition methods, i.e., they rely on the structure of a chemical. The substructures of benzenepropanoic acid, including the ester and amide groups, the phenol groups and the tertiary carbons, are included in the model training sets and were used by the models to derive the physical and chemical properties of this substance.

A literature search was performed, and the program ChemIDplus® (US NLM 2008) was employed to find appropriate analogue substances of benzenepropanoic acid ester. No suitable analogues with measured physical and chemical, and/or persistence and bioaccumulation data were identified through this search. Because of the lack of analogues with measured data identified through the above method, Canada's New Substances database was searched for analogues.

Table 2a. Physical and chemical properties of benzenepropanoic acid ester

Property	Type	Value	Temperature (°C)	Reference
Physical state	Experimental	Solid (powder)	-	Mayzo Inc. (2005)
Melting point (ºC)	Experimental	170–180		Mayzo Inc. (2005)
	Modelled	350		MPBPWIN 2000
Boiling point (ºC)	Modelled	847		MPBPWIN 2000
Density (kg/m^3)	No information available			
Vapour pressure (Pa)	Modelled	4.39×10^{-20} (3.29×10^{-22} mm Hg)	25	MPBPWIN 2000
Henry's Law constant ($Pa \cdot m^3/mol$)	Modelled	9.3×10^{-15} (9.1×10^{-20} $atm \cdot m^3/mole$)	25	HENRYWIN 2000
Log K_{ow} (Octanol-water partition coefficient) (dimensionless)	Modelled	6.68[1]		KOWWIN 2000
Log K_{oc} (Organic carbon-water partition coefficient) (dimensionless)	Modelled, based on K_{OW}	4.32		PCKOCWIN 2000
Water solubility (mg/L)	Measured	< 100	20	Mayzo Inc. (2005)
	Modelled	0.0033[2]	25	WSKOWWIN 2000

Property	Type	Value	Temperature (°C)	Reference
pK_a (Acid dissociation constant) (dimensionless)	Modelled	11.48 (acid form)		ACD/pKaDB 2005

[1] KOWWIN adjusted value based on experimental log K_{OW} value of 7.18 for substance B (see Table 2b)
[2] Modelled based on adjusted Log K_{OW} of 6.68

Analogue data were identified through New Substance Notifications received under the *New Substances Notification Regulations (Chemicals and Polymers)* of CEPA 1999 (Canada 2005). The structures of the two analogues identified are similar to approximately half of the dimer benzenepropanoic acid ester. They contain the hindered phenol structure as well as an aliphatic ester, but they do not contain the amide group. The substances may not be identified for confidentiality reasons. They are identified here as "Substance A" and "Substance B". Physical and chemical property data for these analogue substances are included in Table 2b.

Table 2b. Physical and chemical properties for substances A and B

Property	Substance	Value	Temperature (°C)	Method
Molecular weight (g)	A	334.5		
	B	390.6		
Melting point (ºC)	A	38-45		ASTM E537-86 and Method A1[1]
	B	-20 (pourpoint)		OECD 102
Boiling point (ºC)	A	347 (with decomposition)	100.78 kPa	ASTM E537-86 and Method A2[1]
	B	370 (with decomposition)		OECD (1995b), Method 103
Density (kg/m^3)	A	1030 (1.03 g/mL)	20	Pycnometer and Method A3[1]
	B	959 (0.959 g/mL)	20	OECD (1995d), Method 109
Vapour pressure (Pa)	A	$<1.2 \times 10^{-4}$	25	Method A4[1]
	B	2×10^{-5}	25	OECD (2006), Method 104
Log K_{ow} (Octanol-water partition coefficient) (dimensionless)	A	>4.06		Method A8[1]
	B	7.18		OECD (2004a), Method 117
Log K_{oc}	A	4.23		OECD Draft

(Organic carbon-water partition coefficient (dimensionless)				Guideline (Dec. 1998) (became OECD (2001), Method 121)
	B	>5.63		OECD (2001), Method 121
Water solubility (mg/L)	A	<0.102 0.077	20	OECD (1981), Method 116 WSKOWWIN 2000
	B	<0.121 0.00018[3] 0.00085	20	OECD (1995d), Method 105 WSKOWWIN 2000
Fat solubility (mg/L)	A	Miscible in all proportions	37	OECD (1981), Method 116
	B	NA		
pK_a (Acid dissociation constant) (dimensionless)	A	12.53 (acid form)		[2]Estimated using PALLAS (2001)
	B	NA		

[1] European Commission (1992).
[2] Waivers granted for not measuring its value, as it is expected to be > 10
[3] Apparent water solubility of 0.00018 for Substance B, obtained from algae toxicity study (see Table 7c)
ASTM – American Society for Testing and Materials
OECD – Organisation for Economic Co-operation and Development

In order to directly compare the physical and chemical properties of benzenepropanoic acid ester with the analogues (Substances A and B), the properties of all three substances were modelled in EPIsuite (2008) without any adjustment for empirically determined values, as was done for benzenepropanoic acid ester in Table 2a. This comparison is made in Table 2c, below.

As can be seen by comparing Tables 2a and 2b, the estimated melting and boiling points of benzenepropanoic acid ester are much higher than those measured for the analogue substances. Its modelled vapour pressure is much lower than those measured for the analogues; however, all three substances have low vapour pressures. Almost all properties values for Substance B are more similar to benzenepropanoic acid ester than those of Substance A, including the key properties log K_{OW} and water solubility, which are the most important properties driving bioaccumulation and ecotoxicity.

Empirical data for persistence and toxicity for Substances A and B are used as analogue data for benzenepropanoic acid ester to support the modelled data (see Persistence and

Potential to Cause Ecological Harm Sections of this report). These substances are considered to be adequate analogues for these endpoints. Substances A and B have similar structural features as benzenepropanoic acid ester, so they are expected to be hydrolysed and biodegraded similarly to benzenepropanoic acid ester (see Persistence Section). For toxicity, Substance A and Substance B are expected to have the same mode of toxic action as benzenepropanoic acid ester, as these substances are all esters. Substance B is a better analogue than Substance A, as its predicted log K_{OW} value and water solubility are closer to those of benzenepropanoic acid ester than Substance A's (Table 2c). The predicted log K_{OW} value of Substance B is 0.51 log unit higher than that of benzenepropanoic acid ester and its predicted water solubility is higher but within approximately 1.5 orders of magnitude of benzenepropanoic acid ester. The differences in properties of benzenepropanoic acid ester and Substances A and B and how these affect their predicted or measured toxicities will be further discussed in the Ecological Effects Assessment section.

Table 2c. Comparison of EPIsuite (2008) predicted physical and chemical properties of benzenepropanoic acid ester with Substances A and B

Property	**Benzenepropanoic acid ester**	**Substance A**	**Substance B**
Molecular weight (g)	696.9	334.5	390.6
Melting point (ºC)	349.8	148	172
Boiling point (ºC)	847	398	438
Vapour pressure (Pa)	2.6×10^{-18}	1.5×10^{-5}	6.9×10^{-7}
Log K_{ow} (Octanol-water partition coefficient; dimensionless)	7.92	6.53	8.43
Log K_{oc} (Organic carbon-water partition coefficient; dimensionless)	5.01	4.64	5.68
Water solubility (mg/L)	2.4×10^{-5}	7.7×10^{-2}	8.5×10^{-4}

Sources

Benzenepropanoic acid ester is not a naturally occurring substance.

Information was collected through surveys conducted for the years 2005 and 2006 under *Canada Gazette* notices issued pursuant to section 71 of CEPA 1999 (Canada 2006b, Canada 2009b). These notices requested data on the Canadian manufacture and import of benzenepropanoic acid ester.

Fewer than four companies reported importing a total of 153 kg of benzenepropanoic acid ester in 2006 (Canada 2009b). Fewer than four other companies declared a stakeholder interest in this substance as importers in 2006, so there may be some additional import activity at quantities below the 100 kg/year level. There were no reports of manufacture in, or import into, Canada of benzenepropanoic acid ester above the reporting threshold of 100 kg in the 2005 calendar year (Canada 2006b; Environment Canada 2006). Imports of the substance in 2006 were as a component of chlorinated polyvinyl chloride (CPVC) powder used in sheet, profile and extrusion/injection molding (Environment Canada 2009a). There appears to be much less benzenepropanoic acid ester in commerce in Canada currently than there was two decades ago. The quantity of benzenepropanoic acid ester reported to be manufactured in or imported into Canada during the 1986 calendar year was between 10 000 and 100 000 kg (Environment Canada 1988).

Elsewhere, benzenepropanoic acid ester is listed as a Low Production Volume (LPV) chemical in Europe (ESIS 2009). This chemical was reported under the U.S. Toxic Substances Control Act Inventory Update Rule for the following reporting periods: 1986, 1994, 1998, 2002 and 2006 (US EPA 1986–2002, US EPA 2006). In 2006, less than 500 000 pounds of this substance was produced in or imported into the U.S. (US EPA 2006). In 1998 and 2002, 500 000 to 1 million pounds of this substance was produced in or imported into the U.S. (US EPA 2009). Benzenepropanoic acid ester was used in Sweden in the years 2001 and 2002 at 10 and 15 tonnes per year, respectively (SPIN 2009). It has also been used in Sweden more recently (2003–2007), though quantity information is confidential (SPIN 2009).

Given the use of this substance in other countries, such as in the U.S. to manufacture vehicle components (US EPA 2006), it is probable that the substance is entering the Canadian market as a component of manufactured items. Available information is currently not sufficient to derive a quantitative estimate of the importance of this source.

Uses

In 2006, a Canadian importer of benzenepropanoic acid ester reported that it is used as an antioxidant in chlorinated PVC (CPVC) products (Environment Canada 2009a). CPVC products are used across various industries, such as mass transit, aerospace, fenestration, heating/ventilation/air conditioning, pool and spa, electrical components, irrigation, and mining (information from manufacturer's website, 2009; unreferenced). In Canada, the majority of this substance is sold to a manufacturer of plastic piping. There are no known consumer uses of this substance.

Benzenepropanoic acid ester is used as an antioxidant and thermal stabilizer (Mayzo Inc. 2005). Typical end-use applications include wire and cable insulation, film and sheet manufacture as well as automotive parts. Benzenepropanoic acid ester will stabilize polypropylene, polyethylene, polystyrene, polyester, ethylene propylene diene monomer (EPDM) rubber, ethylene vinyl acetate (EVA), and acrylonitrile butadiene styrene (ABS) (Mayzo Inc. 2005). It is US FDA approved for use in adhesives and polymers with food contact applications at levels not to exceed 0.1% by weight of finished product (Mayzo Inc. 2005.

Fifteen tonnes of benzenepropanoic acid ester were used in Sweden for plastics products manufacturing in 2002 (SPIN 2009).

In the U.S, it was used in motor vehicle seating and interior trim manufacturing as a stabilizer (US EPA 2006).

Releases to the Environment

Releases of benzenepropanoic acid ester to air, water or land, or transfers of the substance to waste management facilities were not reported by any Canadian importers or customers in 2006. (Environment Canada 2009a). There are no known consumer uses of this substance. Given that this substance is imported in solid form, and is used only in industrial applications, releases of this substance to the environment are not expected to be widespread.

The losses of benzenepropanoic acid ester via various routes during its life cycle are estimated based on regulatory survey data, industry data and data published by different organizations. The losses are grouped into six types: (1) discharge to wastewater; (2) emissions to air; (3) emissions to soil; (4) chemical transformation; (5) disposal to landfill; and (6) disposal by incineration. Losses may occur at one or more of the substance's life cycle stages that include industrial use, consumer/commercial use, and disposal. To assist in estimating these losses, a spreadsheet (Mass Flow Tool) was used that incorporates all data and assumptions required for the estimation (Environment Canada 2008, 2009c). Unless specific information on the rate or potential for release of

the substance from landfills and incinerators is available, the Mass Flow Tool does not quantitatively account for releases to the environment from waste disposal sites.

The losses estimated for the 153 kg of benzenepropanoic acid ester imported into Canada over its life cycle for a realistic worst-case scenario are presented in Table 3 (Environment Canada 2009c). In this scenario, the discharge to wastewater pertains to untreated wastewater discharges (e.g., no on-site industrial wastewater treatment or off-site municipal sewage treatment). In general, loss to wastewater is a common source for releases to water through wastewater treatment facilities and to soil through the application of biosolids. The loss via chemical transformation refers to changes in substance identity that occur within the manufacture, industrial use, or consumer/commercial use stages, but excludes those during waste management operations such as incineration and wastewater treatment.

The end use of plastic products (i.e., plastic piping) accounts for the largest proportion (8%) of releases to the environment (soil and/or wastewater), while industrial conversion/compounding of benzenepropanoic acid ester into plastic products accounts for only 0.043% (Environment Canada 2009c). It was assumed that half of the releases from the plastic piping during its service life is to water and half to soil (from pipe that is either buried in or sits on top of the soil). The releases are dispersive (i.e., a large number of very small sources), but the total releases to the environment, i.e., to wastewater and soil, are small (6.1 kg to each – see Table 3).

Table 3. Estimated losses of benzenepropanoic acid ester during its life cycle

Type of loss	Proportion (%)	Mass (kg)	Pertinent life cycle stages
Wastewater	4.0	6.1	Industrial use, consumer/commercial use
Air emission	0.0	0.0	
Soil	4.0	6.1	Consumer/commercial use
Chemical transformation	0.0	0.0	
Landfill	89.2	136	Disposal
Incineration	2.8	4.3	Disposal

Benzenepropanoic acid ester is not expected to be released to the environment via routes other than wastewater and soil. The majority of this substance will be disposed of in landfill. Given this substance's high K_{OW} and K_{OC} values, it is predicted to adsorb strongly to soil and sediment; thus significant leaching into groundwater is not expected.

This substance is expected to be found in manufactured items and consumer products (see Uses section above). Although no information is available on the quantity of manufactured items and consumer products containing benzenepropanoic acid ester that are imported into Canada, it is anticipated that the proportions lost to the various routes would not be significantly different from those estimated here. That said, the quantities released to the environment and sent for waste management would be higher if

importation of these items were taken into consideration; however, available information is currently not sufficient to derive a quantitative estimate for these losses.

Environmental Fate

Based on its physical and chemical properties (Table 2a), the results of Level III fugacity modelling (Table 4) suggest that benzenepropanoic acid ester is expected to predominantly reside in soil and/or sediment, depending on the compartment of release.

Table 4. Results of the Level III-fugacity modelling (EQC 2003)

	Percentage of substance partitioning into each compartment			
Substance released to:	**Air**	**Water**	**Soil**	**Sediment**
Air (100%)	0.40	0.28	86.4	13.0
Water (100%)	0	2.1	0	97.9
Soil (100%)	0	0	99.9	0.13

If released to air, very little of the substance remains in air. The negligible modelled vapour pressure (4.39×10^{-20} Pa) and very low Henry's Law constant (9.3×10^{-15} $Pa \cdot m^3/mol$) indicate that benzenepropanoic acid ester is non-volatile. Therefore, if released solely to air, it will partition to soil and to a lesser degree to sediment.

If released to water, benzenepropanoic acid ester will strongly adsorb to suspended solids and sediment (~98%) based upon a high estimated log K_{oc} (4.32). Volatilization from water surfaces is an unimportant fate process, based upon this substance's estimated Henry's Law constant. Thus, if water is a receiving medium, benzenepropanoic acid ester will mainly partition into sediment (see Table 4).

Benzenepropanoic acid ester is expected to have high adsorptivity to soil (i.e., is expected to be immobile) based upon its high estimated log $K_{oc.}$ Volatilization from moist soil surfaces will be an unimportant fate process, based upon its estimated Henry's Law constant. Therefore, if released to soil, benzenepropanoic acid ester will remain in soil (see Table 4).

The relatively high first acid dissociation constant (pK_a) of 11.5 for the amide functional groups (ACD/pKaDB 2005) indicates that half of the chemical will be dissociated at pH 11.5. In water bodies at environmentally relevant pH (6–9), 100% will be undissociated, which indicates that biotic exposure to benzenepropanoic acid ester will be from the neutral chemical. The relatively low proportion of dissociated chemical also indicates that partitioning behaviour predicted using the log K_{ow} and log K_{oc} is appropriate.

Persistence and Bioaccumulation Potential

Persistence

No experimental data on the degradation of benzenepropanoic acid ester were found. Therefore, a quantitative structure-activity relationship (QSAR) and analogue-based weight-of-evidence approach (Environment Canada 2007) was applied using the data shown in Tables 5a, 5b and 5c below.
Table 5a summarizes the results of available QSAR models for degradation in various environmental media. Empirical hydrolysis and biodegradation data were identified for analogue substances A and B (refer to Physical and Chemical Properties section) and are presented in Tables 5b and 5c below.

Components of benzenepropanoic acid ester's structure are well covered by the model training sets in EPIsuite (2008), which includes the BIOWIN (2000) biodegradation model, and the Arnot-Gobas (2003) and BCFWIN (2000) bioaccumulation models. This is because these models account for the following substructures of benzenepropanoic acid ester: aromatic alcohol, ester, amide, tertiary carbon with no hydrogens, and alkyl substituent on aromatic ring.

According to the Canadian POPs Model (CPOPs 2008) output, benzenepropanoic acid gets a score of 92% for the structure domain. The CPOPs training set contains substances with esters and benzenes and di-tert-butyl phenol structures, and so adequately models this substance.

Table 5a. Modelled data for degradation of benzenepropanoic acid ester

Fate process	Model and model basis	Model result and prediction	Extrapolated half-life (days)
AIR			
Atmospheric oxidation	AOPWIN 2000	$t_{1/2}$ = 2.08 hours	< 2
Ozone reaction	AOPWIN 2000	n/a[1]	n/a
WATER			
Hydrolysis	HYDROWIN 2000	$t_{1/2}$ = 1.03 years (pH 7) $t_{1/2}$ = 38 days (pH 8)	n/a
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 3: Expert Survey (ultimate biodegradation)	0.94[2] "biodegrades slowly"	> 182[4]
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 4: Expert Survey (primary biodegradation)	3.0[2] "biodegrades fast"	< 182[4]
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 5: MITI linear probability	0.20[3] "biodegrades slowly"	> 182[4]
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 6: MITI non-linear probability	0.005[3] "biodegrades very slowly"	> 182[4]
Biodegradation	TOPKAT 2004	-2.5[3]	> 182[4]

(aerobic)	Probability	"biodegrades very slowly"	
Biodegradation (aerobic)	Canadian POPs Model (CPOPs 2008) % BOD (biological oxygen demand)	% BOD = 6.3 "biodegrades very slowly"	> 182[4]

[1] Model does not provide an estimate for this type of structure.
[2] Output is a numerical score from 0 to 5.
[3] Output is a probability score.
[4] Expected half-lives for BIOWIN, TOPKAT and CPOPs models are determined based on Environment Canada 2009b.

In air, a predicted atmospheric oxidation half-life value of 2.08 hours via reactions with hydroxyl radicals (Table 5a) demonstrates that this substance will be rapidly oxidized. The substance is not expected to react with other photo-oxidative species in the atmosphere, such as O_3. Therefore, reactions with hydroxyl radicals will be the most important fate process in the atmosphere for benzenepropanoic acid ester, and it is considered not persistent in air.

A predicted hydrolysis half-life value of 1.03 years at pH 7 and 38 days at pH 8 (see Table 5a) demonstrates that this substance is amenable to hydrolysis under alkaline conditions. Exposed to a portion of the environmentally relevant pH range for surface waters (typically 6–9), the substance is expected to be resistant to hydrolysis. Benzenepropanoic acid ester will have a half-life of less than 38 days at pH values above 8, a half-life of 1.03 years at pH values between 7 and 8 and a half-life of > 1 year at pH values below 7. These modelled predictions are very similar to the measured hydrolysis data for analogue substances A and B (Table 5b).

Table 5b. Empirical data for hydrolysis of analogue substances A and B

Substance	Test method	Temperature (°C)	pH	Half-life
A	C7 of 92/69/EEC[1]	25	4, 7 9	> 1 year 28.9 days
B	OECD (2004b), Method 111	25	4,7 8	> 1 year 15.2 days[2]

[1]European (Economic) Commission (1992)
[2] 1% acetonitrile solution was added as a co-solvent, since the substance is not very soluble. Therefore, the hydrolysis half-lives in pure water would be slower than those given here.

Table 5c. Empirical data for biodegradation of analogue substances A and B

Substance	Test method	Description	Biodegr. value	Time (d)	Conclusion
A	OECD 301B[1]	Aerobic, CO_2 evolution	6%	28	Not readily biodegradable

B	Japanese MITI OECD 301C[1]	Aerobic, BOD[2]	3%	28	Not readily biodegradable

[1]OECD (1992)

[2]BOD = biological oxygen demand

All of the biodegradation models, except for the BIOWIN primary biodegradation model, predict that benzenepropanoic acid ester will biodegrade slowly (Table 5a), suggesting that its ultimate degradation half-life in water would be > 182 days. Although BIOWIN predicts that the substance will undergo relatively fast primary degradation, the identity of the degradation products is not known. The ultimate degradation model predictions are supported by the empirical data for the analogue substances (Table 5c), which conclude that these substances are not readily biodegradable. Therefore, the weight of evidence suggests that the ultimate biodegradation half-life of benzenepropanoic acid ester is > 182 days in water.

Using an extrapolation ratio of 1:1:4 for a water:soil:sediment biodegradation half-life (Boethling et al. 1995), the ultimate biodegradation half-life in soil is also > 182 days and the half-life in sediments is > 365 days. This indicates that benzenepropanoic acid ester is persistent in soil and sediment as a function of biotic degradation processes.

Given that benzenepropanoic acid ester is not expected to partition significantly to air, modelling of its long-range transport potential was not performed.

Benzenepropanoic acid ester hydrolyzes slowly at pH values below 8, and therefore will be stable in many Canadian surface waters. It also does not biodegrade quickly, as the hindered phenolic structure is resistant to biodegradation. Thus, the modelled and analogue data (Tables 5a, 5b and 5c) demonstrate that benzenepropanoic acid ester meets the persistence criteria in water, soil and sediment (half-lives in soil and water ≥ 182 days and half-life in sediment ≥ 365 days), but does not meet the criteria for persistence in air (half-life of ≥ 2 days) as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Potential for Bioaccumulation

The log K_{ow} value of 6.68 for benzenepropanoic acid ester (Table 2a) suggests that it has the potential to bioaccumulate in the environment. Since no experimental bioaccumulation factor (BAF) or bioconcentration factor (BCF) data for benzenepropanoic acid ester were available, a predictive approach was applied using available BAF and BCF models as shown in Tables 6a and b below. According to the *Persistence and Bioaccumulation Regulations* (Canada 2000) a substance is bioaccumulative if its BCF or BAF is ≥ 5000; however, measures of BAF are the preferred metric for assessing bioaccumulation potential of substances. This is because the BCF may not adequately account for the bioaccumulation potential of substances via

the diet, which predominates for substances with log K_{ow} > ~4.0 (Arnot and Gobas 2003). Kinetic mass-balance modelling is in principle considered to provide the most reliable prediction method for determining the bioaccumulation potential because it allows for metabolism correction as long as the log K_{ow} of the substance is within the log K_{ow} domain of the model.

The Arnot-Gobas kinetic model (2003) corrected for metabolic rate within the BCFBAF (2008) Program of EPIsuite was used to model the BCF and BAF of benzenepropanoic acid ester (Table 6a). The middle trophic level fish was used to represent overall model output as it is most representative of the fish weight likely to be consumed by an avian or terrestrial piscivore. The predicted biotransformation rate constant (k_M value) was too high as indicated in the model output, and therefore a default value of 25/day was used for a 10 g fish. According to the Help file for the BCFBAF program:

> For molecules with fragments that appear to be readily biotransformed (e.g., see regression coefficients for esters, ureas, etc.), the model may predict very fast $k_{M,N}$ values. When the model predicts values that exceed proposed whole body maximum rate constant values (Arnot et al. 2008), the whole body maximum values are provided and recommended to replace the original model predictions.

This is what occurred with benzenepropanoic acid ester, due to the readily biotransformed ester group.

Additional modelled BCF data for benzenepropanoic acid ester are shown in Table 6b.

Table 6a. Fish BAF and BCF predictions for benzenepropanoic acid ester using the Arnot-Gobas (2003) kinetic model corrected for metabolic transformation

Test organism	Endpoint	Value wet weight (L/kg)	Reference
Fish	BAF	0.98	Gobas BAF Middle Trophic Level (Arnot and Gobas 2003)
Fish	BCF	0.95	Gobas BCF Middle Trophic Level (Arnot and Gobas 2003)

Table 6b: Additional modelled data for bioaccumulation of benzenepropanoic acid ester

Test organism	Endpoint	Value wet weight (L/kg)	Reference
Fish	BCF	6.7	Dimitrov et al. 2005
Fish	BCF	300	BCFWIN 2000

The modified Gobas BAF middle trophic-level model for fish predicted a bioaccumulation factor (BAF) of 0.98 L/kg, indicating that benzenepropanoic acid ester

does not have the potential to bioconcentrate in fish and to biomagnify in food webs (Table 6a). The results of BCF model calculations (Table 6b) provide additional evidence supporting the low bioconcentration potential of this substance. Based on the available kinetic-based modelled values corrected for metabolism and considering empirical evidence for metabolic potential, benzenepropanoic acid ester does not meet the bioaccumulation criterion (BCF or BAF $\geq$ 5000) as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Potential to Cause Ecological Harm

Ecological Effects Assessment

A - In the Aquatic Compartment

There is modelled evidence that benzenepropanoic acid ester, and experimental evidence that analogues of benzenepropanoic acid ester, cause harm to aquatic organisms at relatively low concentrations (see Tables 7a, 7b, and 7c below).

A range of aquatic toxicity values were obtained from various QSAR models, including EPIsuite (2008), OASIS Forecast (2005) and AIEPS (2003–2007), as shown in Table 7a. The predictions in Table 7a are valid, as none of the maximum K_{ow} and molecular weight cut-off values specified in the models were exceeded. The AIEPS model does not employ any cut-off values for parameters such as $K_{OW,}$ etc. The AIEPS (2003–2007) training set is not ideal for benzenepropanoic acid ester, as it does not contain any di-tert butyl phenols. Benzenepropanoic acid ester is modelled as a "reactive, unspecified" by OASIS, which suggests an ester mode of action and toxicity above baseline narcosis.

In EPIsuite (2008), the toxicity of benzenepropanoic acid ester was modelled as an ester, a polyphenol, and also as a neutral organic (baseline toxicity); however, the log K_{OW} cut-off for the esters class is 5.0 (for acute values) instead of 7.0 for the polyphenols class; therefore, only the acute results for the polyphenols class are shown in Table 7a. Given that concentrations for both the toxicity and water solubility are often uncertain, toxicity values that exceeded solubility estimates by up to a factor of 10 were considered to be acceptable. Most of the toxicity predictions exceeded the predicted water solubility of this substance (0.0033 mg/L) by more than a factor of 10; therefore, no effects at saturation are predicted (ECOSAR 2004). The results from ECOSAR for the three chemical classes that did not exceed the solubility of this substance by more than a factor of 10 were the chronic values for fish, daphnid (polyphenols class) and mysid shrimp (esters class) (see Table 7a). Based on these toxicity predictions, benzenepropanoic acid ester has the potential to cause chronic harm to aquatic organisms at low concentrations (< 0.1 mg/L).

Table 7a. Modelled data for aquatic toxicity for benzenepropanoic acid ester

Test organism	Type of test	Endpoint	Value[1] (mg/L)	Reference
Fish	Acute (96 hours)	LC_{50}[2]	0.12*	ECOSAR 2004
			≤ 0.19*	OASIS Forecast 2005
			4.01*	AIEPS 2003–2007
	Chronic (30 days)	-	0.016	ECOSAR 2004
Daphnia	Acute (48 hours)	LC_{50}[2]	≤ 0.15*	OASIS Forecast 2005
			18.3*	AIEPS 2003–2007
	Chronic (21 days)	-	0.021	ECOSAR 2004
	Acute	EC_{50}[3]	51.8*	AIEPS 2003–2007
Algae	Chronic	-	0.10*	ECOSAR 2004
Mysid Shrimp (seawater)	Chronic	-	0.0001	ECOSAR 2004

[1] Values followed by * exceed the predicted water solubility by more than a factor of 10. All results are for the polyphenols class except for the mysid shrimp value, which is for the esters class.
[2] LC_{50} – The concentration of a substance that is estimated to be lethal to 50% of the test organisms.
[3] EC_{50} – The concentration of a substance that is estimated to cause some effect on 50% of the test organisms.

Empirical toxicity data for analogue substances A and B are presented in Tables 7b and 7c, respectively.

The concentration and stability of the test material in the test solutions were verified by chemical analysis at the beginning and end of the acute tests, and every few days throughout the *Daphnia* reproduction study.

For Substance B, "Although the concentrations found in the…test samples were in some instances only just above that of the LOQ the results obtained were considered to be valid.". More details about this can be found in the Robust Study Summary for the algae study in Appendix I.

For Substance A, the lowest effect value was the measured lowest observed-effect concentration (LOEC) of 0.11 mg/L from the *Daphnia* reproduction study (Table 7b). For Substance B, no toxic or sublethal effects were observed in rainbow trout or *Daphnia magna* at the highest achievable dissolved concentration levels (Table 7c). The lowest effect value was the LOEC of 0.00018 mg/L (measured concentration) from the algae study (Table 7c). This concentration is considered to be the water solubility limit of this substance, according to the study report.

Table 7b. Empirical data for aquatic toxicity of analogue substance A

Test organism	Type of test	Endpoint	Value[1] (mg/L)
Algae (*Desmodesmus subspicatus*)	Chronic (96 hours), growth, growth rate	EC_{50}[2] NOEC[3]	> 1000 (> 1.24*) 1000 (1.24*)
Daphnia magna	Acute (48 hours)	EC_{50}[2] NOEC[3]	110 (0.27) 56 (NA)
Daphnia magna	Reproduction (21 days)	EC_{50}[2] LOEC[4] NOEC[3]	20 (NA) 32 (0.11) 10 (0.048)
Rainbow trout (*Oncorhynchus mykiss*)	Acute (96 hours)	LC_{50}[5] NOEC[3]	1500 (NA) 560 (0.66)

[1] Given values are loading rates for the water accommodated fraction, not measured concentrations. Values in parentheses are average measured concentrations over the duration of the study. Values followed by * exceed the predicted water solubility of 0.08 mg/L by more than a factor of 10.
[2] EC_{50} – The concentration of a substance that is estimated to cause some effect on 50% of the test organisms.
[3] NOEC – The no-observed-effect concentration is the highest concentration in a toxicity test not causing a statistically significant effect in comparison to the controls.
[4] LOEC – The lowest-observed-effect concentration is the lowest concentration in a toxicity test that caused a statistically significant effect in comparison to the controls.
[5] LC_{50} – The concentration of a substance that is estimated to be lethal to 50% of the test organisms.
NA – not available

Table 7c. Empirical data for aquatic toxicity of analogue substance B

Test organism	Type of test	Endpoint	Value[1] (mg/L)
Algae (*Desmodesmus subspicatus*)	Chronic (72 hours), growth, growth rate	EC_{50}[2] LOEC[3] NOEC[4]	> 100 (> 0.00018) 100 (0.00018) 50 (0.00014)
Daphnia magna	Acute (48 hours)	EC_{50}[2] NOEC[4]	100 (> 0.0082) 100 (0.0082)
Rainbow trout (*Oncorhynchus mykiss*)	Acute (96 hours)	LC_{50}[5] NOEC[4]	100 (> 0.0011) 100 (0.0011)

[1] Given values are loading rates for the water accommodated fraction, not measured concentrations. Values in parentheses are average measured concentrations over the duration of the study.
[2] EC_{50} – The concentration of a substance that is estimated to cause some effect on 50% of the test organisms.
[3] LOEC – The lowest-observed-effect concentration is the lowest concentration in a toxicity test that caused a statistically significant effect in comparison to the controls.
[4] NOEC – The no-observed-effect concentration is the highest concentration in a toxicity test not causing a statistically significant effect in comparison to the controls.
[5] LC_{50} – The concentration of a substance that is estimated to be lethal to 50% of the test organisms.

Substance A has a predicted log K_{OW} value 1.39 log units lower than benzenepropanoic acid ester and a predicted water solubility three orders of magnitude higher than this substance (see Table 2c). Substance A is therefore likely more bioavailable than benzenepropanoic acid ester. Based on its log K_{OW} value which is higher than that of benzenepropanoic acid ester (see Table 2c), Substance B appears to be somewhat less bioavailable than benzenepropanoic acid ester, but somewhat more bioaccumulative. Its

measured toxicity for algae (LOEC of 0.00018 mg/L; Table 7c) is similar to the lowest valid predicted value for benzenepropanoic acid ester (mysid shrimp chronic value of 0.0001 mg/L; Table 7a).

Based on the above modelled and analogue data (Tables 7a, 7b and 7c), including the *Daphnia* reproduction study for Substance A and the algae study for Substance B, there is evidence that benzenepropanoic acid ester has the potential to cause harm to aquatic organisms following longer-term (chronic) exposure at low concentrations.

B - In Other Environmental Compartments

No ecological effects studies were found for this compound in media other than water.

Mammalian data were found and considered in the Potential to Cause Harm to Human Health section of this report.

Ecological Exposure Assessment

No data concerning concentrations of this substance in the environment in Canada or elsewhere have been identified; therefore environmental concentrations in water have been estimated from available information, including substance quantities, estimated release rates, and information on the size of receiving water bodies, as described below.

A - Consumer Release

A release scenario based on uses of manufactured products containing benzenepropanoic acid ester was not performed, as these releases are expected to be widely dispersed, compared to concentrated point-source releases produced by industrial operations. In Canada the largest use of this substance is in plastic piping (Environment Canada 2009a). Releases to the environment of benzenepropanoic acid ester from the use of plastic piping are expected to be quite low (approximately 12 kg/year; see Table 3), as described in the Releases to the Environment section.

B - Industrial Release

As benzenepropanoic acid ester is used industrially and is expected to be released to water, a realistic worst-case industrial release scenario was developed (Environment Canada 2009d), to estimate the aquatic concentration of the substance. The scenario was made conservative by assuming that the total quantity of the substance used by Canadian industry (153 kg) is used by one single industrial facility at a small, hypothetical site. The loss to sewer was assumed to be 0.055%, which is the loss for a realistic worst-case scenario involving an open process for compounding and conversion of plastics,

according to the Emission Scenario Document for plastics additives (OECD 2004). The scenario also assumes that the release occurs 250 days per year, typical for small and medium-sized facilities, and is sent to a local sewage treatment plant (STP). Removal rates of 92.4%, 98.5% and 78.7% were estimated using the sewage treatment plant models SimpleTreat (1997), STP Model (2001) and ASTreat (2006), respectively (Environment Canada 2009e). The ASTreat result, which conservatively assumes that the substance is non-biodegradable, was used in the calculation. In Canada, the receiving water at such a small site normally has a 10-fold dilution capacity for the STP effluent. Of the 1074 known Canadian municipal discharge sites, 66% have a dilution factor of greater then 10 at the 10th percentile of flow (Environment Canada 2009f). The STP flow rate is conservatively assumed to be 3456 m^3/day, which is the 10^{th} percentile of STP effluent flow rates across Canada (Environment Canada 2009f).

The equation and inputs used to calculate the predicted environmental concentration (PEC) of benzenepropanoic acid ester in the receiving water bodies are described in Environment Canada (2009g, 2009h). Based on the above assumptions, the aquatic PEC is very low (2.1×10^{-6} mg/L) (Environment Canada 2009g).

Characterization of Ecological Risk

Benzenepropanoic acid ester is a data-poor substance. Most physical and chemical property data are estimated, and no measured data on its persistence, bioaccumulation, or toxicity were found. However, two analogue substances with measured data were identified, and these analogue substances were deemed to be appropriate as comparison substances, based on their structures and the physical and chemical property data (refer to Physical and Chemical Properties Section).

The approach taken in this ecological screening assessment was to examine various supporting information and develop conclusions based on a weight-of-evidence approach and using precaution as required under CEPA 1999. Lines of evidence considered included results from a conservative risk quotient calculation, as well as information on persistence, bioaccumulation, toxicity, sources and fate of the substance.

Benzenepropanoic acid ester is expected to be persistent in water, soil and sediment, and is expected to have a low bioaccumulation potential. The low importation volume of this substance into Canada, along with information on its uses, indicate low potential for releases into the Canadian environment. Once released into the environment, it will partition mainly to soil and sediment. It has been demonstrated to have high potential for inherent toxicity to aquatic organisms.

A risk quotient analysis, integrating conservative estimates of exposure with toxicity information, was performed for the aquatic medium to determine whether there is potential for ecological harm in Canada. A realistic worst-case exposure scenario for manufacturing of plastic products containing benzenepropanoic acid ester, presented in

the Environmental Exposure section above, yielded a PEC of 2.1 x 10^{-6} mg/L. The predicted no-effect concentrations (PNEC) was based on the lowest-observed-effect level (LOEL) from the algal growth inhibition study for Substance B (0.00018 mg/L; see Table 7c), as almost all of the QSAR-based toxicity predictions showed no effects at saturation (Table 7a). The PNEC was derived by dividing this LOEL by an assessment factor of 10 to account for interspecies and intraspecies variability in sensitivity, giving a PNEC of 0.000018 mg/L. The resulting risk quotient (PEC/PNEC) is equal to 0.1. Therefore, based on the Canadian realistic worst-case exposure scenario, harm to aquatic organisms from benzenepropanoic acid ester is unlikely.

When benzenepropanoic acid ester is released into a water body, it is predicted to partition primarily into suspended particulate matter and to bottom sediments (see Table 4), where sediment-dwelling organisms would be exposed to the substance. A risk quotient for benzenepropanoic acid ester based on exposure in sediment pore water may be calculated based on the aquatic compartment predicted environmental concentration (PEC) and predicted no effects concentration (PNEC) values presented in the Ecological Exposure Section below and used for sediment risk characterization. In the calculation, bottom sediment and its pore water are assumed to be in equilibrium with the overlying water, and benthic and pelagic organisms are assumed to have similar sensitivities to the substance. Therefore the PEC and PNEC for pore water is considered to be the same as for the aquatic compartment. This equilibrium approach would result in a risk quotient (PEC/PNEC) for the sediment compartment that is the same as for the aquatic compartment.

A quantitative analysis of risk to soil organisms was not possible, given the lack of soil toxicity data. However, no effects on soil organisms are anticipated, based on the low import volume and releases of this substance, and the resulting low exposure.

Uncertainties in Evaluation of Ecological Risk

There are no experimental data for most of the physical and chemical properties, persistence, bioaccumulation, and toxicity of benzenepropanoic acid ester. However, the modelled estimates are valid and are considered to be reliable, as the structural components of this substance are well covered by the model training sets. Moreover, the modelled results agreed reasonably well with the empirical data for the analogue substances, in that no effects are seen at the water solubility limits of the substances in most cases, but in some cases, there are effects at or just below the water solubility limits.

Regarding ecotoxicity, based on the predicted partitioning behaviour of this chemical, the significance of soil and sediment as important media of exposure is not well addressed by the effects data available. Indeed, the only effects data identified apply primarily to pelagic aquatic exposures, although the water column is not the medium of primary concern based on partitioning estimates (see Table 4)

Given the use of this substance in other countries, such as the U.S., it is possible that the substance is entering the Canadian market as a component of manufactured items and consumer products. The estimated quantities of benzenepropanoic acid ester released to the environment and sent for waste management would be higher if importation of these items were taken into consideration. However, estimates of releases of benzenepropanoic acid ester based on its end uses are very low. Available information is currently not sufficient to derive a quantitative estimate for the releases from imported items and from waste disposal sites.

Potential to Cause Harm to Human Health

Exposure Assessment

There were no data identified for concentrations of benzenepropanoic acid ester in air, water, soil or sediment, in Canada or elsewhere. Given the amount imported into Canada on an annual basis, concentrations of this substance in environmental media are expected to be negligible.

Following an industry submission in 1982, Health Canada evaluated exposure to benzenepropanoic acid ester from its use in food packaging as an antioxidant in both high- and low-density polyethylene (i.e., HDPE and LDPE), at a level of use of 0.1% for products in contact with fatty foods and 0.5% for products in contact with all other kinds of foods. It was also evaluated for use in polypropylene and high-impact polystyrene at levels of 0.5% for products in contact with all kinds of foods. The probable daily intake (PDI) was estimated to be 20 µg/kg-bw (November 2009 e-mail from Food Directorate to Risk Management Bureau, Health Canada; unreferenced). Since 1982, Health Canada has not received any other submissions regarding the use of benzenepropanoic acid ester in plastics used for food packaging, which indicates that this substance is not likely to be currently used for this purpose.

Benzenepropanoic acid ester may also be used as an antioxidant in plastics available to consumers, such as wire and cable insulation, automotive parts, and piping (Mayzo Inc. 2005). Residual concentrations of benzenepropanoic acid ester in these products is unknown but is expected to be low, and therefore exposure from consumer products would not be significant.

Overall confidence in the exposure characterization for environmental, dietary and consumer product exposures is considered to be low due to the lack of experimental data. There is uncertainty in the exposure to benzenepropanoic acid ester through these routes; however, given that the amount imported into Canada is very small, exposure to the general population is expected to be minimal.

Health Effects Assessment

Some empirical toxicological data are available for benzenepropanoic acid ester. No evidence of mutagenicity was observed in *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA1538 exposed to benzenepropanoic acid ester with or without metabolic activation (Jonmaire et al. 1985). A one-generation reproductive study in rats fed diets containing 0, 2000, 6325 or 20 000 ppm of benzenepropanoic acid ester for 72 days resulted in significantly decreased body weights and decreased food consumption at 2000 ppm in parental males and females. Pups in the high-dose group had a significant increase in body weight up to day 14 but were comparable to controls by day 21

(November 2009 e-mail of unpublished study from Food Directorate, to Risk Assessment Bureau, Health Canada; unreferenced). In a 90-day study, using 30 of the F1 generation rats from the reproductive study, animals were fed diets containing 0, 2000, 6325 or 20 000 ppm benzenepropanoic acid ester. The only effects observed were increased relative liver weights in females at 2000 ppm and in both males and females at the mid and high-dose groups (November 2009 e-mail of unpublished study from Food Directorate to Risk Assessment Bureau, Health Canada; unreferenced). A sub-chronic (90-day) feeding study was conducted in male and female beagle dogs exposed to 0, 2000, 6300 and 20 000 ppm benzenepropanoic acid ester in the diet. Analysis of body weight, food consumption, organ weights, hematology, clinical chemistry, urine analysis and histopathology of the control and high-dose groups were conducted. Prothrombin times were decreased in females at the mid and low doses compared to controls; however the group mean prothrombin time was within normal limits and the high-dose group females were comparable to the controls. The authors concluded that it was difficult to attribute biological significance to this finding (Jonmaire et al. 1985). The acute toxicity is low, with an LD_{50} in rats of > 10 g/kg (Jonmaire et al. 1985).

The outputs of predictive models were also considered using four different models, DEREK, TOPKAT, CASETOX and Leadscope Model Applier, of which the predictions for carcinogenicity, genotoxicity, developmental toxicity, and reproductive toxicity were predominately negative (DEREK 2008; TOPKAT 2004; CASETOX 2008; Leadscope 2009). A summary of the model outputs are shown in Appendix III.

Characterization of Risk to Human Health

The principal source of exposure to benzenepropanoic acid ester for the general population is expected to be through food (i.e., migration from food packaging). A comparison between a conservative lowest-observed-effect level for benzenepropanoic acid ester of 2000 ppm (converted to 60 mg/kg-bw/day, based on conversion factors in Health Canada 1994) for increased relative liver weights in female F1 generation rats and very limited evidence of decreased prothrombin time observed in female dogs and the probable daily intake estimated in food (20 µg/kg-bw) results in a margin of exposure of approximately 3000. This margin is considered adequate to account for uncertainties in the database in light of the conservative nature of the estimates of exposure and effect level, and the likelihood that this substance is no longer used in food packaging plastics.

Uncertainties in Evaluation of Risk to Human Health

Although some data are available for benzenepropanoic acid ester, the confidence in the toxicological dataset is considered to be low to moderate, especially for chronic exposure. However, the available empirical data and information from predictive models are not suggestive of high hazard.

Conclusion

Based on the information presented in this screening assessment, it is concluded that benzenepropanoic acid ester is not entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity, or that constitute or may constitute a danger to the environment on which life depends. Additionally, it meets the criteria for persistence but does not meet the criteria for bioaccumulation potential as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

It is also concluded that benzenepropanoic acid ester is not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

It is therefore concluded that benzenepropanoic acid ester does not meet any of the criteria under section 64 of CEPA 1999.

This substance will be considered for inclusion in the *Domestic Substances List* inventory update initiative. In addition and where relevant, research and monitoring will support verification of assumptions used during the screening assessment.

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Appendix I. Robust Study Summary for Algal Toxicity Study for Substance B

Robust Study Summary Form				
No	**Item**	**Weight**	**Yes/No**	**Specify**
1	Algal Growth Inhibition Study for Substance B			
2	Substance identity: CAS RN	n/a		
3	Substance identity: chemical name(s)	n/a		
4	Chemical composition of the substance	2	Y	
5	Chemical purity	1	Y	> 99%
6	Persistence/stability of test substance in aquatic solution reported?	1	Y	Substance unstable – concentration declined over duration of test. Results based on geometric mean measured concentrations.
Method				
7	Reference	1	Y	OECD 201
8	OECD, EU, national, or other standard method?	3	Y	
9	Justification of the method/protocol if a non-standard method was used	2	n/a	
10	GLP (good laboratory practice)	3	Y	
Test organism				
11	Organism identity: name	n/a		*Desmodesmus subspicatus*
12	Latin or both Latin and common names reported?	1	Y	
13	Life cycle age / stage of test organism	1	NA	
14	Length and/or weight	1	NA	
15	Sex	1	NA	
16	Number of organisms per replicate	1	Y	Cell densities reported
17	Organism loading rate	1	Y	
18	Food type and feeding periods during the acclimation period	1	NA	
Test design/conditions				
19	Test type (acute or chronic)	n/a		72 h
20	Experiment type (laboratory or field)	n/a		Lab
21	Exposure pathways (food, water, both)	n/a		Water
22	Exposure duration	n/a		72 h
23	Negative or positive controls (specify)	1	Y	Positive control – potassium dichromate Negative control – no test substance added
24	Number of replicates (including controls)	1	Y	3 replicates for each concentration, 6 replicates for controls
25	Nominal concentrations reported?	1	Y	6.25, 12.5, 25, 50, 100%v/v saturated solution

26	Measured concentrations reported?	3	Y	
27	Food type and feeding periods during the long-term tests	1	n/a	
28	Were concentrations measured periodically (especially in the chronic test)?	1	Y	Concentrations measured at 0 and 72 hours
29	Were the exposure media conditions relevant to the particular chemical reported? (e.g., for the metal toxicity - pH, DOC/TOC, water hardness, temperature)	3	Y	
30	Photoperiod and light intensity	1	Y	Constant illumination
31	Stock and test solution preparation	1	Y	
32	Was solubilizer/emulsifier used if the chemical was poorly soluble or unstable?	1	N	No solubilizers used, though chemical is poorly soluble. Special method used to create test solution.
33	If solubilizer/emulsifier was used, was its concentration reported?	1	n/a	
34	If solubilizer/emulsifier was used, was its ecotoxicity reported?	1	n/a	
35	Analytical monitoring intervals	1	Y	Cell densities measured at 0, 24, 48 and 72 hours
36	Statistical methods used	1	Y	
37	Was the endpoint directly caused by the chemical's toxicity, not by the organism's health (e.g. when mortality in the control > 10%) or physical effects (e.g., shading effect)?	n/a	Y	
38	Was the test organism relevant to the Canadian environment?	3	Y	
39	Were the test conditions (pH, temperature, DO, etc.) typical for the test organism?	1	Y	
40	Do system type and design (static, semi-static, flow-through; sealed or open; etc.) correspond to the substance's properties and the organism's nature/habits?	2	Y	Static, non-renewal
41	Was pH of the test water within the range typical for the Canadian environment (6 to 9)?	1	Y	pH = 7.2–7.3
42	Was temperature of the test water within the range typical for the Canadian environment (5 to 27°C)?	1	Y	24°C
43	Was toxicity value below the chemical's water solubility?	3	Y	LOEC at water solubility limit; NOEC below
Results				

44	Toxicity values (specify endpoint and value)	n/a		EC_{50}(growth rate) > 0.00018 mg/L
45	Other endpoints reported - e.g., BCF/BAF, LOEC/NOEC (specify)?	n/a		LOEC = 0.00018 mg/L, NOEC = 0.00014 mg/L
46	Other adverse effects (e.g. carcinogenicity, mutagenicity) reported?	n/a	n/a	
47	***Score*: ... %**			***45/45 = 100%***
48	***Environment Canada reliability code*:**			
49	***Reliability category (high, satisfactory, low)*:**			***High***
50	***Comments***	Due to the low aqueous solubility of the substance, special methodology was used to prepare the test solutions, which involved stirring the test material into the test water for 24 to 96 hours at a high loading rate to produce a saturated solution. No solubilizers were used. After stirring, the aqueous phase was removed by mid-depth siphoning and was centrifuged at 40 000 g for 30 min to produce the 100% v/v saturated solution. This saturated solution was then diluted to prepare the test concentrations. Range-finding tests were done where the solution was filtered; however analysis of the filtered test samples showed measured concentrations of less than the limit of quantitation (LOQ) regardless of the pre-conditioning volume used indicating that the test material was absorbing to the filter matrix. "However observations made on the saturated solution showed it to be a clear, colourless solution and hence if any dispersed material was present it was present at such a low level to not exert any physical effects on the test organisms." "Although the concentrations found in the…test samples were in some instances only just above that of the LOQ the results obtained were considered to be valid. … In this particular case procedural recoveries were run alongside the test samples to account for any analytical variation that may have occurred. Whilst these results were outside of the normal acceptance criteria of 80–120% they were considered to show that the sensitivity of the method of analysis was satisfactory at the low test concentrations employed and that therefore the measured test concentrations obtained were valid."		

Appendix II – PBT Model Inputs Summary Table

	Phys-Chem/Fate	**Fate**	**Fate**	**Fate**	**PBT Profiling**	**Ecotoxicity**
Model input parameters	EPIsuite (all models, including: AOPWIN, KOCWIN, BCFBAF, BIOWIN and ECOSAR)	STP (1) ASTreat (2) SimpleTreat (3) (required inputs are different depending on model)	EQC (required inputs are different if Type I vs. Type II chemical)	Arnot-Gobas BCF/BAF Model	Canadian-POPs (including: Dimitrov Model, OASIS Toxicity Model)	Artificial Intelligence Expert System (AIEPS)
SMILES Code	O=C(C(=O)NCCOC(=O)CCc1cc(c(c(c1)C(C)(C)C)O)C(C)(C)C)NCCOC(=O)CCc2cc(c(c(c2)C(C)(C)C)O)C(C)(C)C				Same as EPIWIN	Same as EPIWIN
Molecular weight (g/mol)	696.93	696.93	696.93			
Melting point (ºC)	175		175			
Boiling point (ºC)						
Data temperature (ºC)			20			
Density (kg/m^3)		1.36				
Vapour pressure (Pa)		4.4×10^{-20}	4.4×10^{-20}			
Henry's Law constant (Pa·m^3/mol)		4.30×10^{-19}	1.0×10^{-11}			
Log K_{aw} (Air-water partition coefficient) (dimensionless)						
Log K_{ow} (Octanol-water partition coefficient) (dimensionless)	6.68	6.68	6.68	6.68	6.68	
Log K_{oc} (Organic carbon-water						

partition coefficient – L/kg)						
Water solubility (mg/L)	0.0033	0.0033	0.0033			
Log K_{oa} (Octanol-air partition coefficient) (dimensionless)						
Soil-water partition coefficient (L/kg)[1]		1.0×10^5				
Half-life in air (hours)			1.04			
Half-life in water (days)			273			
Half-life in sediment (days)			819			
Half-life in soil (days)			273			
Metabolic rate constant (1/days)				25/day		
Biodegradation rate constant (1/days) or (1/hr) -specify		0.0159 1/hr (3) 0.38 1/days(2)				
Biodegradation half-life in primary clarifier ($t_{1/2-p}$) (hr)		436 (1)				
Biodegradation half-life in aeration vessel ($t_{1/2-s}$) (hr)		43.6 (1)				
Biodegradation half-life in settling tank ($t_{1/2-s}$) (hr)		43.6 (1)				

[1] derived from log K_{oc}
[2] derived from BCF data
[3] default value

Appendix III: Summary of (Q)SAR Results for benzenepropanoic acid ester

(Q)SAR PREDICTIONS ON CARCINOGENICITY

Model/ Species	Mice		Rat		Rat	Mice	Rodent	Mammal
	Male	Female	Male	Female				
Model Applier	N	N	N	N	N	N	N	-
Multicase Casetox	NR	NR	N	N	-	-	NR	-
Topkat	NR	NR	NR	NR	-	-	-	-
Derek	-	-	-	-	-	-	-	NR

MA – Model Applier
CT – Multicase Casetox
TK – Topkat
TT – Toxtree
BB – Benigni-Bossa rule
ND – Not in domain
'-' No model available in QSAR suite
NR – No result
N – Negative
P- Positive

(Q)SAR PREDICTIONS ON GENOTOXICITY

Model/endpoints	chromosomal abberations.	chromosomal abbberations - other rodent	chromosomal abbberations - rat	micronucleus mice	micronucleus rodent	drosophila	drosophila heritable translocations	drosophila SLRL	mam. mutation	mam. mutation dominant lethal	UDS	UDS human lymphocytes	UDS rat hepatocytes	mouse lymphoma mut	*S. cerevisiae*	yeast	hgprt	*E. coli*	*E coli* w	microbial	salmonella	BB cancer alert
MA	ND	ND	ND	N	N	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	N	N	-
CT	N	-	-	NR	-	NR	-	-	-	-	NR	-	-	P	-	-	-	-	-	-	N	-
TK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NR	-
TT	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	N

MA – Model Applier
CT – Multicase Casetox
TK – Topkat
TT – Toxtree
BB – Benigni-Bossa rule
ND – Not in domain
'-' No model available in QSAR suite
NR – No result
N – Negative
P- Positive

(Q)SAR PREDICTIONS ON DEVELOPMENTAL TOXICITY

Model Applier

Endpoint/ Species	Mice	Rabbit	Rat	Rodent
Retardation	ND	ND	N	N
Weight decrease	ND	ND	N	N
Fetal death	ND	ND	N	N
Post implantation loss	ND	ND	N	N
Pre implantation loss	ND	ND	N	N
Structural	ND	ND	N	N
Visceral	ND	-	N	N

Multicase Casetox

Endpoint/Species	Hamster	Mammal	Miscellaneous
Teratogenicity	-	P	NR
Developmental	NR	-	-

MA – Model Applier
CT – Multicase Casetox
TK – Topkat
TT – Toxtree
BB – Benigni-Bossa rule
ND – Not in domain
'-' No model available in QSAR suite
NR – No result
N – Negative
P- Positive

(Q)SAR PREDICTIONS ON REPRODUCTIVE TOXICITY

Model Applier

Model/ endpoint	Female			Male		
Species	Mice	Rat	Rodent	Mice	Rat	Rodent
Repro	ND	N	N	ND	P	N
Sperm	-	-	-	ND	N	N

Multicase Casetox

Mice	Rat	Rabbit	Human
NR	NR	NR	NR

MA – model Applier
CT – Multicase Casetox
TK – Topkat
TT – Toxtree
BB – Benigni-Bossa rule
ND – not in domain
'-' no model available in QSAR suite
NR – no result
N – Negative
P- Positive